Geologic Character and Temporal Framework of Long Cores from the New Jersey Margin: Final Sample Analysis and Data Synthesis for the ONR GEOCLUTTER Initiative

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LONG-TERM GOALS

The primary long-term goal of this project is to provide a detailed understanding of the stratigraphic significance of buried geologic structure on the New Jersey shelf and the interaction of buried geologic structures with acoustic energy from tactical sonars. A second goal is to provide updated, quantitative relationships between physical and geotechnical properties of sediments in support of acoustic model development for the seabed.

OBJECTIVES

The objectives of this year's activities are: 1) to finalize analysis and synthesis of core data from the 2002 New Jersey shelf cruise to ground-truth the geophysical data from the Geoclutter study areas; 2) analyze and integrate other cores from the NJ margin into existing datasets and 3) synthesize acoustic data from the Geoclutter, CA Strataform and other pertinent areas into physical-geoacoustic relationships.

APPROACH

1) *Complete textural analysis of 2002 Cores*
The goals of and protocols for the textural analyses of the long cores were determined by close consultation with the acousticians, geophysicists and geologists such that the data will be useful for geoacoustic modeling studies and geologic interpretations. The necessary sampling interval is 10-cm (approximating the resolution of the Chirp seismic source), which provided approximately 320 samples for detailed grain size.

2) *Complete ^{14}C Time-Stratigraphic Evaluation of 2002 Cores*
Samples collected at strategic intervals throughout the drill cores were analyzed using AMS techniques at the Center for Applied Isotope Studies at the University of Georgia. Samples represented all sediment types sampled and sediments on either side of important stratigraphic boundaries.

3) *Subsample, Analyze and Integrate Other Existing Core Material and Data*

a) Analysis of Cores Collected from the Marion Dufresne II on the New Jersey margin.

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Existing cores, collected in 1999 from the Marion Dufresne II under ONR sponsorship, represent another source of material to use in extending our knowledge of the New Jersey margin. Samples from appropriate cores broaden our spatial and temporal information on the upper tens of meters of the seabed.

b) Synthesis of Acoustic-Physical Property Data
Existing physical property and MST logger data from the CA Strataform area have been examine to determine relationships between these data that can be useful in geoacoustic modeling. MST data was gathered on the long piston cores collected with the Marion Dufresne II and on the long drill cores collected from the RV Knorr in 2002. Addition of all this data, as appropriate, to the large dataset already in existence should provide a more robust model of geoacoustic relationships than can the CA Strataform data alone.

4) *Coordinate and Integrate Results with GEOCLUTTER Group*
The communication and integration of results within interdisciplinary research programs is critical to gain the highest return for the time and money invested. Group meetings, individual, geologically oriented publications, as well as integrative papers with Geoclutter colleagues all form avenues to synthesize and distribute final products. Research results are stored in an ArcGIS database to facilitate data sharing within the research group.

WORK COMPLETED

1) *Complete textural analysis of 2002 Cores*
A total of 303 samples have been analyzed for detailed textural analysis during the past year. These samples have been analyzed at 0.25-phi intervals in the coarse and fine size ranges to delineate any subtle differences that might be present.

2) *Complete ^{14}C Time-Stratigraphic Evaluation of 2002 Cores*
All high-quality samples for detailed age control of the cores have been analyzed for ^{14}C age using AMS techniques. Twenty-one samples of shell and woody material have been analyzed out of a total 63 samples collected for this purpose. These materials were collected during core splitting on the ship or in a later trip to Lamont to collect dateable material, not immediately visible to the naked eye, identified by examination of the ~120 x-radiographs produced from the cores.

3) *Subsample, Analyze and Integrate Other Existing Core Material and Data*

a) Analysis of Cores Collected from the Marion Dufresne II on the New Jersey margin.
Two hundred sixty-five samples for detailed sediment texture have been collected from five of the long cores collected by the Marion Dufresne II in 1999 (four from the shelf and one from the slope). To assess the utility of these data for integration into the existing physical property relationships, we have analyzed and examined a preliminary subset of the textural data for association with the MST logger data that was collected from the cores immediately after collection on the ship.

b) Synthesis of Acoustic-Physical Property Data
The CA Strataform dataset has been analyzed for bulk physical and acoustic properties calculated from remotely sensed logger data and directly measured porosity and sediment texture. The best empirical relationships between mean grain size, porosity, bulk density, and sound velocity are being determined from this extensive dataset for use by modelers in their models of acoustic response and

sediment properties. The existing CA Strataform physical property and MST data have been combined with an exploratory subset of the Marion Dufresne II sediment data. The MST logger data and sediment data from the 2002 New Jersey cores is presently being integrated into the database with the help of Sommerfield. These updated relationships will be incorporated into a summary publication.

4) *Coordinate and Integrate Results with GEOCLUTTER Group*
I am participating in the development of three synthesis manuscripts (one in press and three in preparation) with others in the Geoclutter research group. In addition to the two papers listed in the publications section, Christensen and I are writing a paper that will integrate her paleoenvironmental insights with my age control and physical environmental interpretations to describe the Quaternary depositional history of the NJ shelf. As the lead scientist for the 2002 coring effort and for much of the core material analysis, I have standardized and maintained the master schedule of core designations, intervals and nomenclature. As new data has been produced in this project, it has been migrated into ArcGIS so that data can be distributed in a standard GIS format.

RESULTS

1) *Completion of textural analysis of 2002 Cores*
Sediment analyses have shown a wide variability in grain size downcore, indicating that variable environments of deposition were present on the NJ shelf during deposition and infill of the shelf channels (Figures 1, 2, 3). This variability suggests that infilling of the channels with sea level rise was not a simple, deepening depositional sequence from estuarine to open ocean conditions, but can be shown to have been a series of repeated depositional sequences, alternating between restricted, estuarine and open, inner-shelf environments. These far-reaching results are arrived at by the powerful combination of texture and other paleoenvironmental indicators (i.e., foraminifera and detrital grain mineralogy; see Christensen annual report).

2) *Complete ^{14}C Time-Stratigraphic Evaluation of 2002 Cores*
Detailed age control of the cores portrays the age structure of the upper tens of meters of the seabed and illustrates the complex nature of the accretion, incision and transgression of the New Jersey shelf (Figures 1, 2, 3). The oldest sediments observed (~35-45Ky) overlie and in site 3 underlie the regional reflector “R”, which is shown by this study to be time-transgressive. This unconformity was formed during periods of intermediate sea level stands during Isotope stage 3. During the subsequent sea level fall these sediments must have been incised and material removed to deeper water, forming the channel systems we sampled, as no materials dating from the period between ~30,000 to 15,000 years have been found. Channel infill exhibits ages from 12,000 to 14,000 years, suggesting that the channels were rapidly infilled shortly after the shoreline migrated landward. The upper meter of the seabed exhibits ages from Modern to ~10,000 years, suggesting that the uppermost meter is routinely and rapidly reworked, eroded and mixed by physical processes.

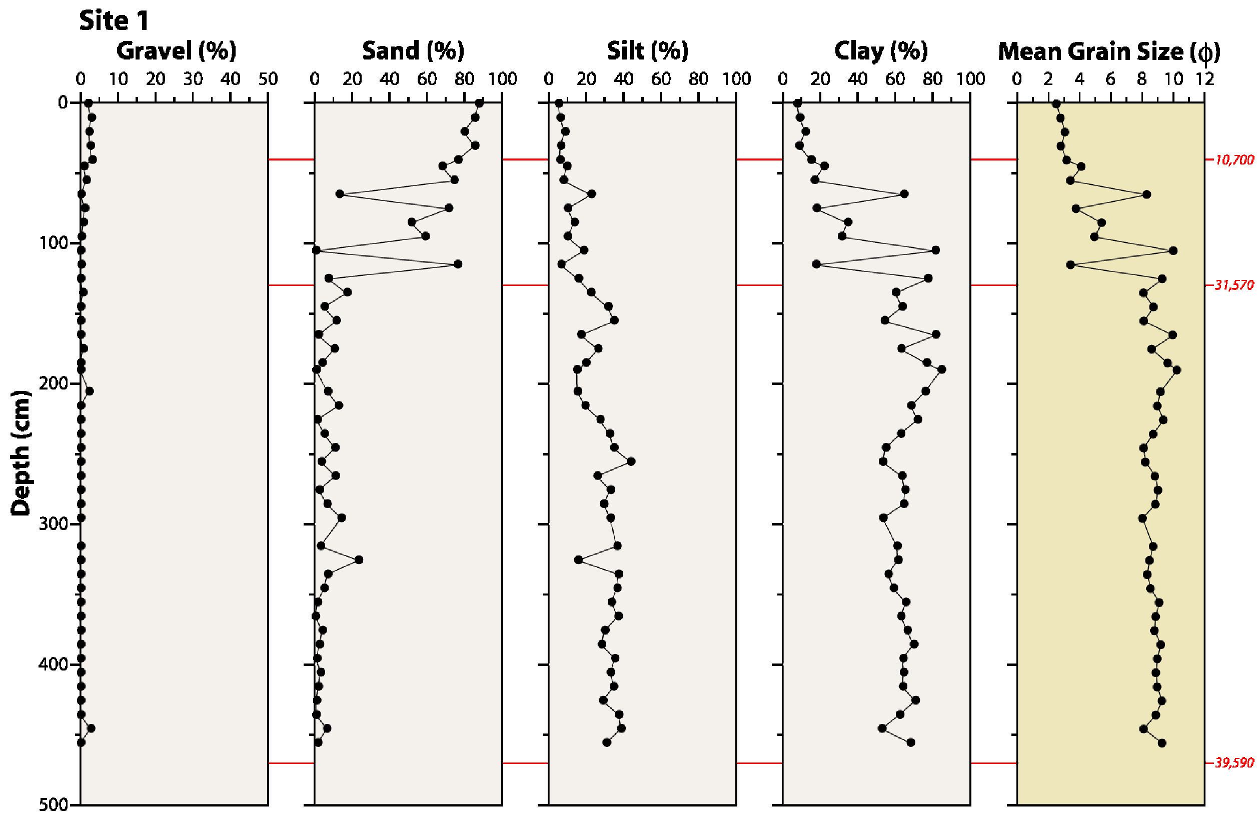

Figure 1: Textural and Age Structure for Site 1

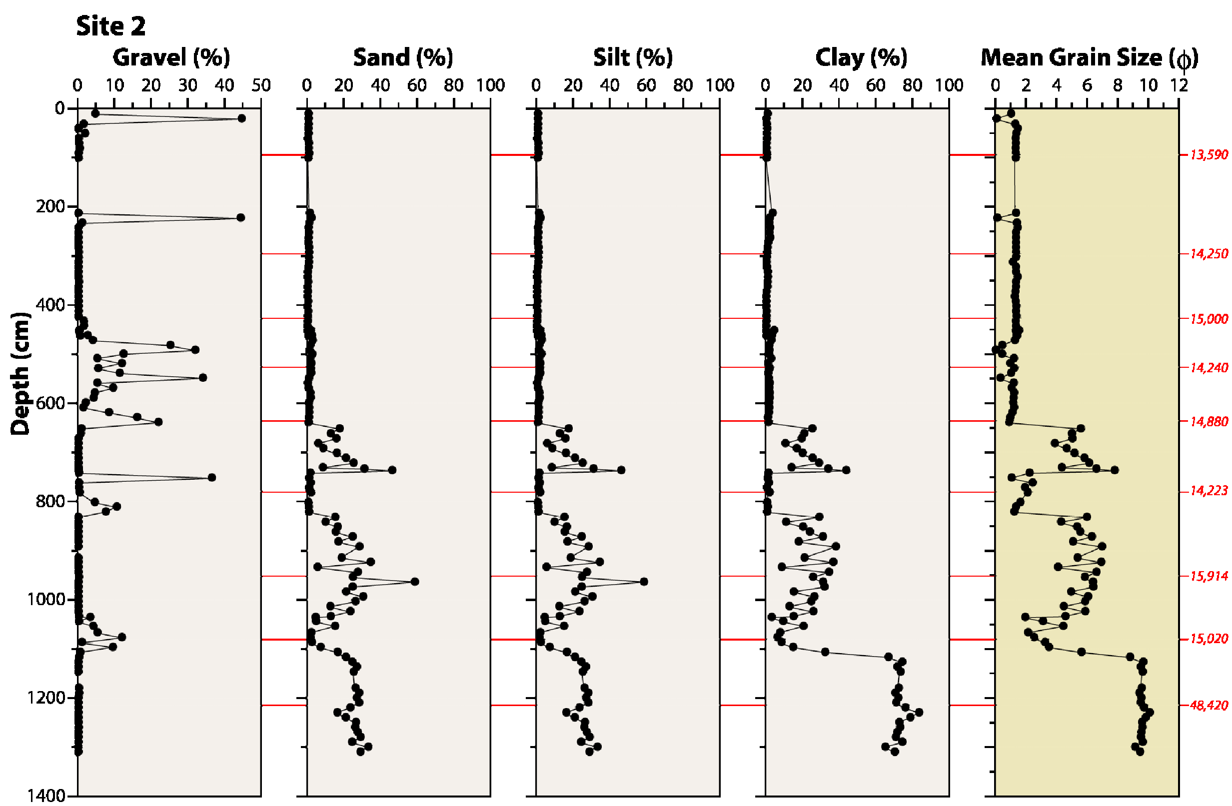

Figure 2: Textural and Age Structure for Site 2

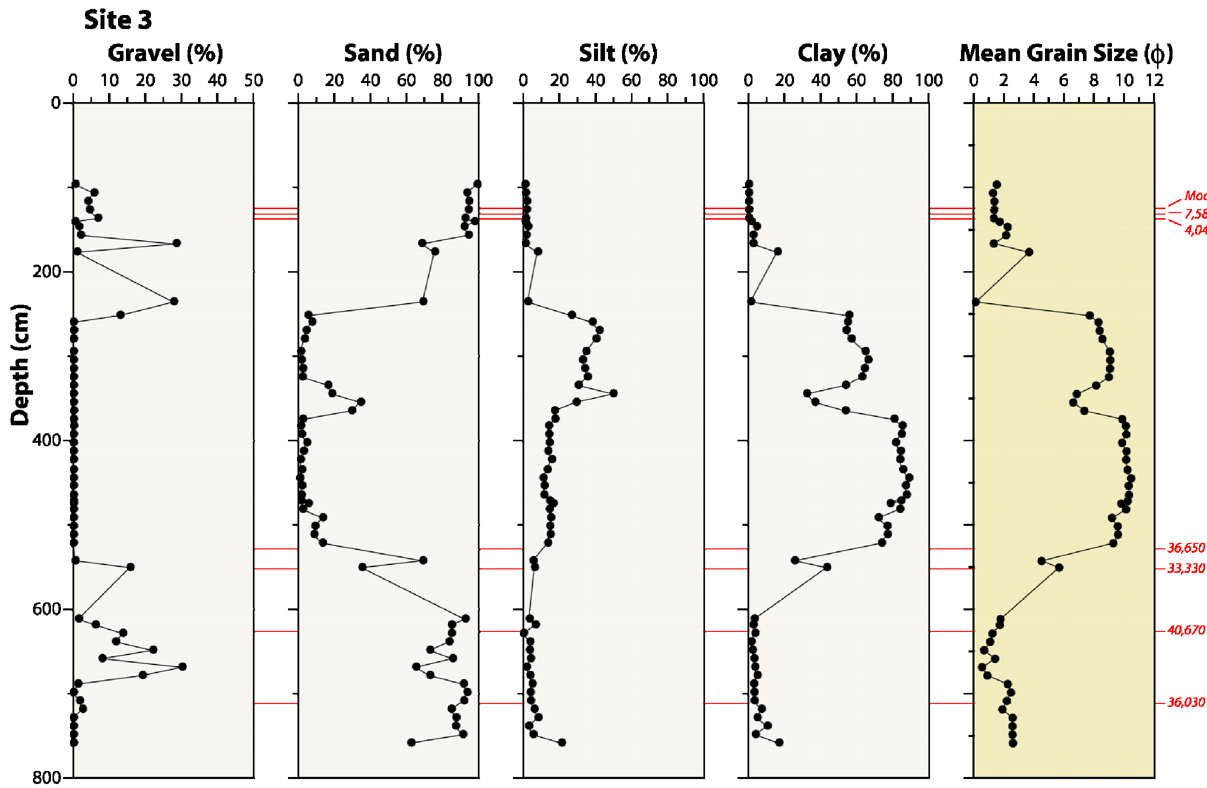

Figure 3: Textural and Age Structure for Site 3

3) *Subsample, Analyze and Integrate Other Existing Core Material and Data*

a) Analysis of Cores Collected from the Marion Dufresne II on the New Jersey margin.
The preliminary analysis of a subset of samples from the Marion Dufresne II (Figure 4), to make sure the additional 200+ sample analysis would be a fruitful exercise, demonstrates that the sediments collected in these cores are uniformly sandy throughout their length (with the exception of the core from the slope – the two outlier triangles in each plot). This result is somewhat disturbing in that all our AHC-800 cores from the New Jersey shelf sampled muddier sediments below about 1-2 meters, whereas the Marion Dufresne cores collected over 7 m of sand in some cases. Analysis of the shelf grain sizes do not show any variation in the sections analyzed so far, suggesting that much of the cores may be flow-in, a condition hard to identify but easy to create in these coarse-grained sediments. Note the wide range of densities and velocities associated with essentially the same textural values, in contrast to the covarying relationships in the Northern California data. These results do not encourage further analysis of the Marion Dufresne II cores and suggest that sandy, shelf cores collected with this system should be examined closely.

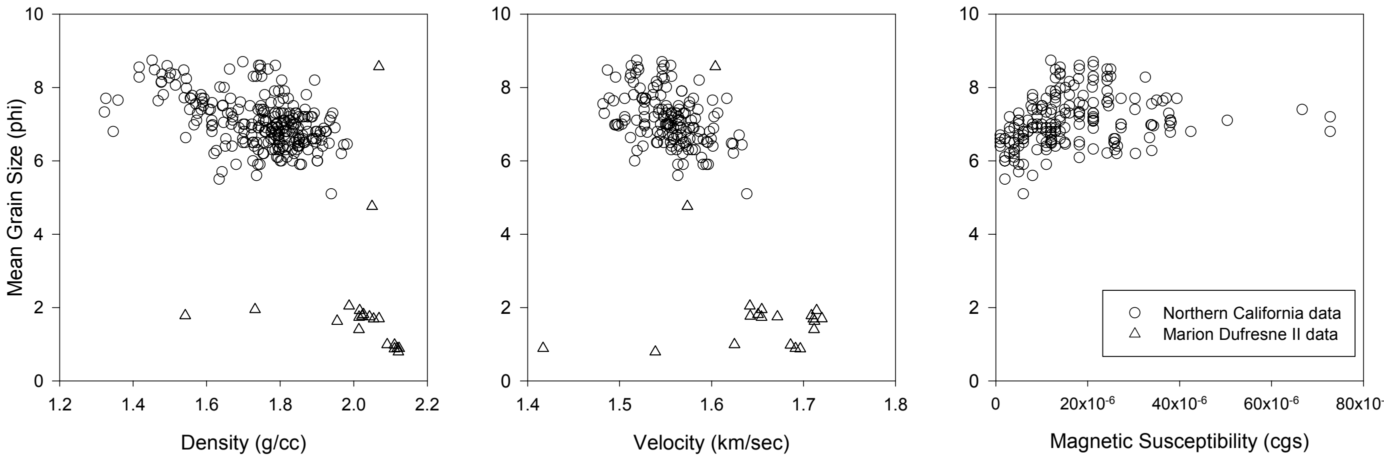

Figure 4: Textural and MST logger data for the Marion Dufresne II cores (triangles)

b) Synthesis of Acoustic-Physical Property Data

Figure 5 shows the preliminary plots of all the CA Strataform data broken up into shelf and slope categories. Relatively well-behaved relationships are observed in the slope data whereas more scatter characterizes the shelf data. The wider range in grain sizes and therefore porosity probably best explains this observation. The relationships are non-linear for velocity and magnetic susceptibility when shelf and slope data are combined. Note that the slope data also have less steep slopes than do the relationships on the shelf. This characteristic has been observed in other studies of sediment geoacoustic properties. When the addition of the 2002 NJ long core data to these present data is completed in collaboration with Sommerfield, a wider range of textures and porosities will be represented from shelf and slope and more robust relationships can be derived. Linear or non-linear trend relationships appropriate to the data will be determined at that time.

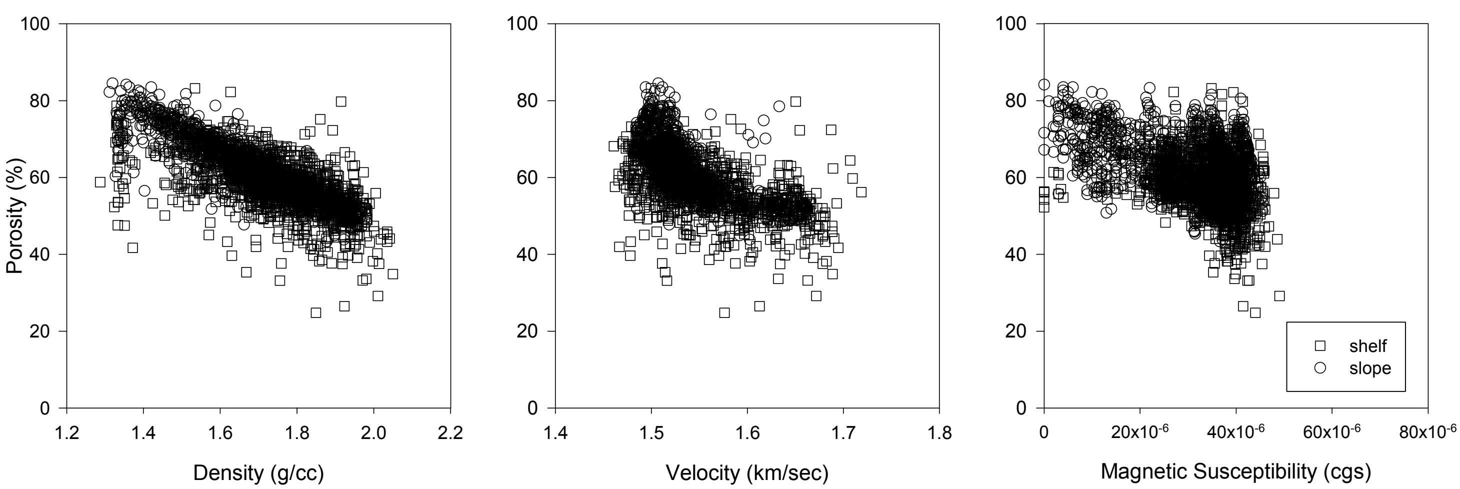

Figure 5: Physical property and geoacoustic data from the CA Strataform site

4) *Coordinate and Integrate Results with Geoclutter Group*
See discussion of results in **WORK COMPLETED** section.

IMPACT/APPLICATIONS

The full impact/applications of these results are just now becoming apparent. The success of the AHC-800 in the field creates tremendous opportunities to examine geologic and geotechnical questions for which the sampling tools did not previously exist. The cores collected in 2002 provide a wealth of material from which to produce acoustic models of the seabed and these data are in the final phases of being integrated and passed on to the acousticians. Physical property measurements from the MST logger, textural data, age control and biostratigraphy are contributing to a better understanding of buried stratigraphic surfaces, their relationship to geologic processes active during past geologic periods and to a better predictive capability for buried structure or geoclutter on margins that are less well known. Over the next few months, final integration of these results across the Geoclutter PIs will yield a dramatic increase in knowledge of NJ geologic history and seabed geoacoustic behavior.

TRANSITIONS

None at this time.

RELATED PROJECTS

Austin, Goff, Fulthorpe, Sommerfield and Christensen have complementary ONR Geoclutter funding to participate in the synthesis of data from the Geoclutter area and I am in close contact with all these researchers. Austin, other UTIG PIs and Nordfjord are examining the high-resolution Chirp data from the shelf, the seismic stratigraphic interpretations of these strata and are interpreting the acoustic stratigraphy observed. Sommerfield is investigating broad-scale surficial texture and subsurface physical properties of the NJ sediments. Christensen is studying the paleoenvironmental indicators contained in the sediments to characterize paleodepositional environments, as well as working closely with me to integrate physical and biological paleoenvironmental data. H. Lee and J. Locat continue to have a strong interest in the physical property data we produce and are providing data for incorporation into the physical property-geotechnical parameter relationships of the seabed.

PUBLICATIONS

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PATENTS

none